DELFT3D-Modelling of Hydrodynamic and Water Quality Processes in San Diego Bight

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This work is in cooperation with Dr. Eric Terrill (SIO Scripps), Dr. Lyle Hibler (PNL) and Mark Moline (CalPoly) who are funded separately.

LONG-TERM GOALS

The long-term goal of this effort is to demonstrate the applicability of the Delft3D hydrodynamic/morphodynamic software system to the case of the hydrodynamics and contaminants dispersal and advection in the San Diego Bight. Delft3D has until now been applied extensively to strongly astronomical, wind and wave-forced (shelf sea and nearshore) conditions but not to the weakly-forced conditions which occur off the California coast. This is of interest to the Navy because of naval operations and the presence of a Navy SEAL training ground just north of the Tijuana River outlet.

OBJECTIVES

The objective of this study is to demonstrate the capabilities of the Delft3D hydrodynamic system by developing a multi-domain (nested) cascade of models ranging from the Southern California Bight scale to the nearshore area around the Tijuana River mouth and Imperial Beach. The model is to be driven with boundary conditions from a larger ocean shelf model (wind, tides, salinity, temperature, etc.) for a number of events (scale of days and weeks), and to be validated against measured data inside the domain.

An analysis will be made of what conditions determine the trapping and mixing of the plume inside the surfzone and/or the propagation of the plume through the breakers and onto the coastal shelf.

The objective of the first year effort are:

- Set up Delft3D model driven by local winds, solar radiation and outer flow boundary conditions provided by an outer model (NCOM) (Deltares, PNNL and SIO)
- Operation of the Delft3D model for San Diego region (PNNL and SIO)
- Optimize outer boundary condition forcing inputs (Deltares) and examine their influence on Delft3D skill compared to observations (in part) (Deltares, PNNL, SIO)

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- Optimize atmospheric condition inputs to Delft3D from COAMPS (Deltares)
- NETCDF data output capabilities in Delft3D (Deltares)
- "Drifter" code modification that allows numerical drifters to move horizontally and vertically in water column. (Deltares)

APPROACH

In this project we have set up a Delft3D sea shelf model, coupled it with a larger-scale model (NCOM) and/or data to provide boundary conditions, including flow boundary conditions and solar radiation. In this way the hydrodynamics of the eddies in the San Diego Bight can be simulated. We use point-source contaminants at the Tijuana River Mouth as input in order to perform simulations of the plume contaminant dispersal and water quality conditions on the San Diego Bight. Specifically, we performed 1-month model simulations at the time of rainfall events (February 2009) to analyze model success at simulating local processes.

In the next phase of the project the deterioration of the model performance through data-denial will be analyzed in order to determine the optimal input of data. Impacts of mixing of the contaminants across the surf zone will be examined. It is expected that in high-surf, in combination with the low river jet momentum conditions, the plume will be trapped within the surf. In contrast, it is expected that in higher river jet momentum conditions, the plume will quickly cross the surf. Additional complexity can occur when high shear is present between the wave-driven long-shore currents within the surf and offshore wind/tidal/pressure gradient forced currents move in opposite directions.Scientific or technological objectives of this effort.

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WORK COMPLETED

- Set up Delft3D model driven by local winds, solar radiation and outer flow boundary conditions provided by an outer model (NCOM). This is done but the model needs to be driven with 3hourly NCOM forcing data in stead of 12 hour forcing data. This data is still pending from data provider.
- Operation of the Delft3D model for San Diego region (PNNL and SIO). The validation is in progress.
- Optimize outer boundary condition forcing inputs (Deltares) and examine their influence on Delft3D skill compared to observations (in part) (Deltares, PNNL, SIO). The sensitivity study has been done (see below).
- Optimize atmospheric condition inputs to Delft3D from COAMPS (Deltares). This has been done.
- NETCDF data output capabilities in Delft3D (Deltares). Done.
- "Drifter" code modification that allows numerical drifters to move horizontally and vertically in water column. (Deltares) Actual tasks completed or technical accomplishments. This is still in progress.

RESULTS

The curvilinear mesh of the San Diego Bight covers the 30 km stretch of coast from Rosarito (Mexico) to Solana Beach see Figure 1. In order to capture the temperature and salinity stratification in San Diego Bight, it is necessary to run the model in 3D mode. For this purpose, 20 vertical sigma layers are defined. The largest vertical density gradients in the model are expected to occur close to the water surface and this is where the highest vertical resolution is required.

Setting up boundary conditions for the model has turned out to be one of the most challenging problems in this project so far. Multiple configurations of boundary condition types, such as water levels, velocity and Neumann (water level gradient) forcing have been tested along the three (southern, western and northern) open boundaries. The application of water level boundaries in the San Diego Bight model often gives rise to large instabilities in the form of high velocity water jets entering the model domain. It is thought that the strong vertical density variation in combination with relatively weak forcing agents (weak tidal currents, low wind velocities) causes these instabilities. The jets cause unrealistic vertical mixing and large velocities inside the model domain. Using current and Neumann boundaries conditions along the lateral boundaries generally causes unrealistic upwelling close to the shore.

An important finding is only the use of Riemann (weakly-reflective) boundaries yielded both stable and realistic results. Although these are more cumbersome to set up (one needs both normal velocities and water levels at each boundary) and to some extent cause some loss of control over the water level inside the model domain.

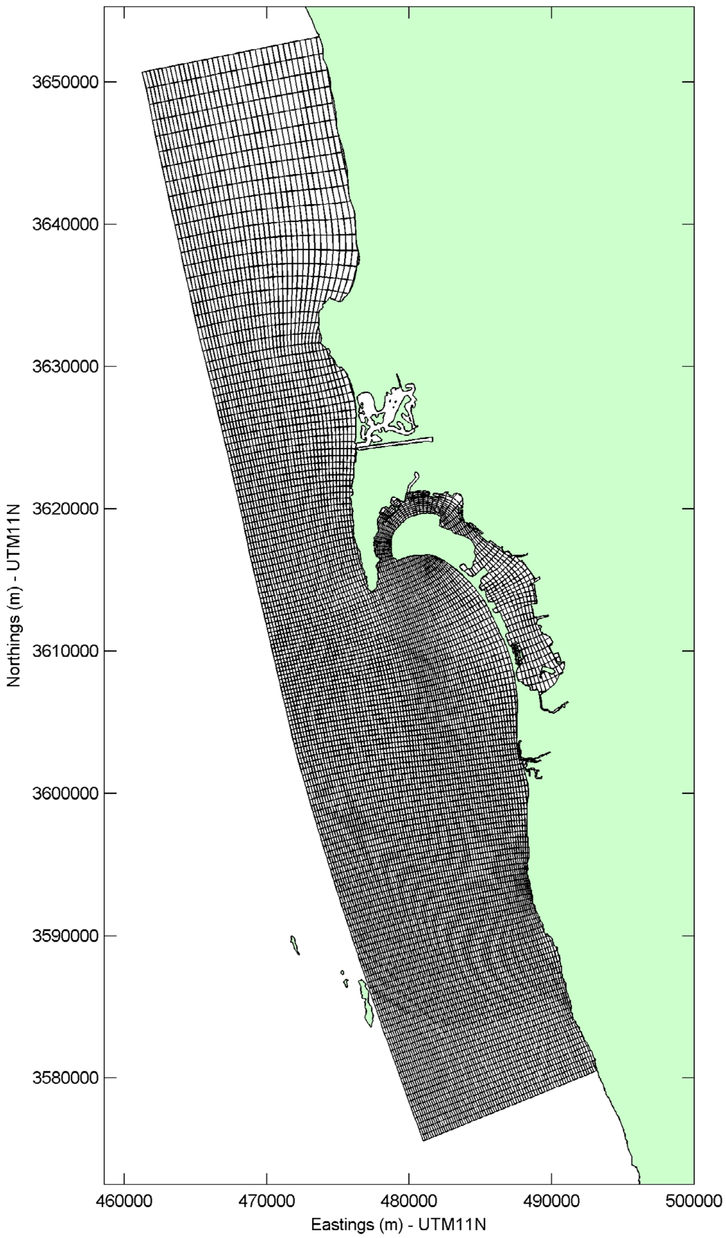
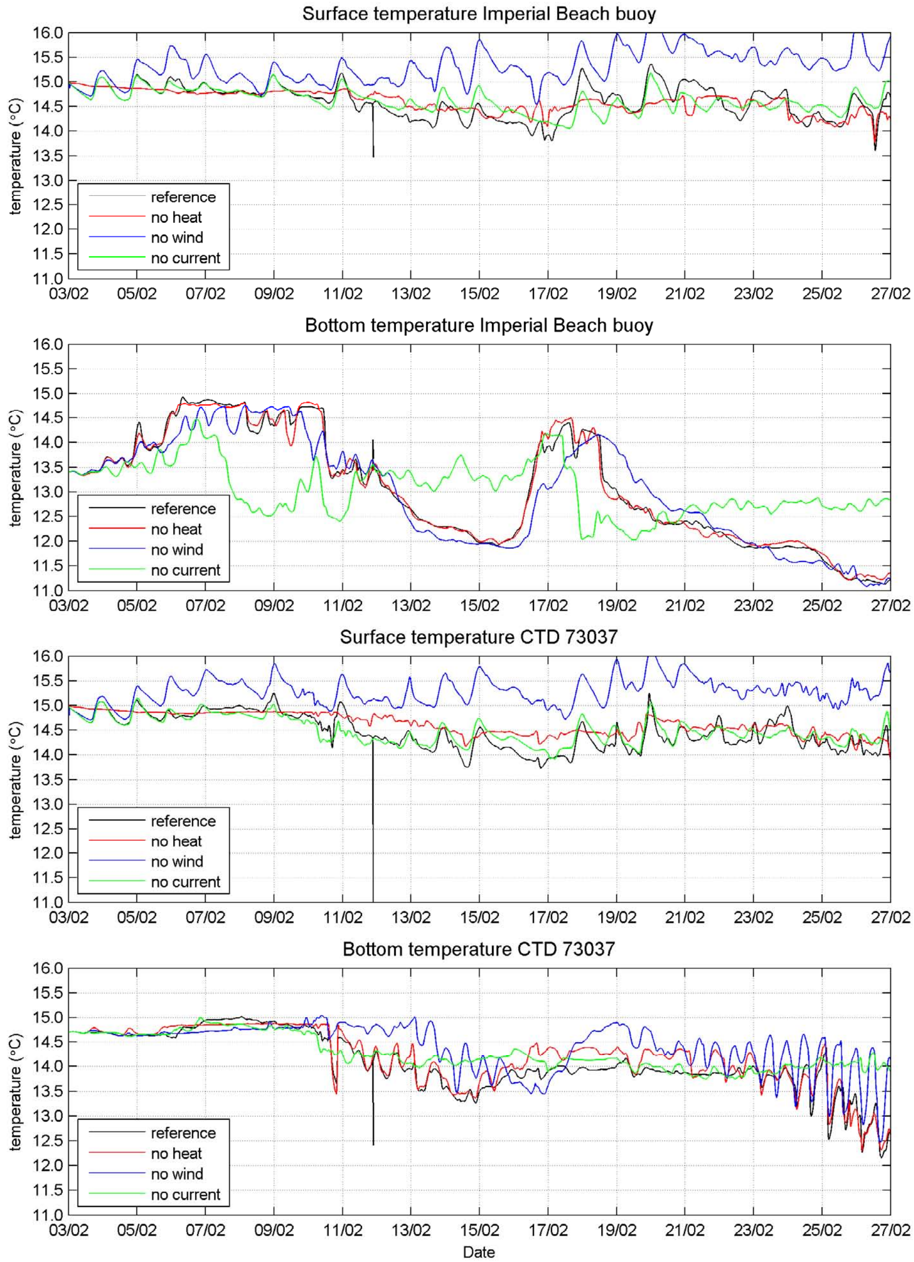


Figure 1 Computational grid San Diego Bight

At this stage in the investigation, it is important to get an estimate of what the model's sensitivity to different input parameters. For this purpose, a sensitivity analysis is carried out in which the following changes have been made with respect to a reference simulation

- No wind
- No heat exchange with the atmosphere
- No currents on the southern boundary
- Manning's bed roughness coefficient changed from 0.020 to 0.024
- Horizontal eddy viscosity and diffusivity changed from 0.1 m1/2/s to 1m1/2/s

Results are shown in the following figure and indicate that it is important to have wind forcing , heat exchange and currents on the boundary all turned on in the model, i.e. no process is dominant.



IMPACT/APPLICATIONS

The model results so far show that the Delft3D model is capable of simulation the essential processes in the San Diego Bight and can be forced by an outer model, and wind forcing. This tool has the potential to deliver real time forecasting/nowcasting capabilities in this region.

TRANSITIONS

The Delft3D model software and code is accessible to ONR under the existing DELFT3D license of contract N00014-02-C-075, dated October 3, 2002.

RELATED PROJECTS

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